ADULTERATION OF FOOD.

A LECTURE

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In dealing with the question of adulteration it is necessary that we should have a clear idea of what, by law, adulteration may be defined to be. Adulteration, or breach of the Food and Drugs Act, then, is, first, the mixing, or colouring, or staining, or powdering any article of food, drink, or medicine with any ingredient which would render such food, &c., injurious to health. This would apply to products in whatever form they might exist. Next, the sale of an article of food or drug which is not of the nature, substance, or quality demanded by the purchaser. This would apply to all natural products, whether such are sold in their natural state or are only changed in form without requiring any sensible addition of extraneous matter—as flour into bread, coffee from the raw to the roasted state, milk, butter, cheese. Secondly, the sale of any compounded article of food, drink, or drugs which is not composed of ingredients in accordance with the demand of the purchaser. Under the head of compounded articles would be included all artificial effervescing drinks, gin, beer and porter, chocolate, butterine, and many others. None of these exist naturally, and all are made by the mixture of various substances in the process of manufacture.

The last Adulteration Act, or, as it is called, Food and Drugs Act, is a great improvement upon its predecessor, but itself can scarcely be regarded as complete. The most important defect in the Act, if one were compelled to accept it as final, is that in no case does it set up a single standard to guide the analyst in deciding upon the real extent of adulteration. The want of such a standard is nowhere so evident as in the case of milk, which is, we know, both for the very old and the very young, the staff of life. The present low standard adopted by analysts is based upon

the poorest milk one cow has produced. Now the Manchester milk supply, as the figures given below will show, is at least 11½ per cent less than its proper value—that is if its proper value ought to be represented by the milk supplied by the dairies of cows which are kept in the neighbourhood; and we can scarcely assume, as is frequently done in defending cases of adulteration, that all Manchester is supplied from one miserable half-starved cow. Mr. Carter Bell gives as the average of the milk of 126 cows, from dairies many of which form part of the sources of supply for Manchester, solids, 13·3 per cent. I myself, in analysing milks taken in an adjoining borough, under such conditions as proved them to be genuine milks, found an average of 13·1 per cent. Now, during the year 1877 I found the average of the milk samples purchased in Manchester gave 11·76 total solids, which, calculated upon the basis of milk as supplied from the cows, gives the percentage loss upon the milk supply of Manchester as 11·9 per cent. If, therefore, Manchester could obtain its milk pure from the cow the gain in money alone would be equal to £24,000 per annum. (Supposing that each of the 70,000 houses in Manchester required an average of one pint each daily, at twopence per pint, this would = £210,000.) From what has been said respecting milk alone it is evident that some fair, well-defined standard, which could be obtained from the results of the analysis of the milk of hundreds of cows, and which ought never to be based upon the milk of less than two cows to a dairy, would greatly improve the milk supply of large towns. It would be a still greater boon if standards for all articles of food could be laid down by competent authorities; and so much progress has been made in food analysis during the last four years that no insurmountable difficulty exists to prevent this.

Flour and Bread.—In treating of the adulterations of flour, it is of course apparent that bread is also included, the only adulterant of one, that is bread, which is not practicable in the case of flour being the addition of an excessive quantity of water. This end is obtained by using rice or potato flour, and the presence of more than 47 per cent of water would itself cause the analyst to suspect the presence of one or both of these foreign starches. The microscope is in this case the only method of detecting this addition, and as the difference between wheaten flour and the flour of either rice or potato is very well marked, the presence of either in the quantity which (to pay) must be introduced is readily detected. The possible adulterants of flour are legion—only to name them would occupy considerable time. I shall, therefore, content myself

with naming those which are most commonly in use. Popular prejudice in favour of a white loaf has caused the use of alum in this country, whilst on the Continent the public are occasionally treated to an additional dainty in the form of sulphate of copper, better known as blue vitriol. Flour adulterated with alum gives, when made into bread, instant evidence of such adulteration directly what is called the logwood test is applied. Bread made from pure flour gives no such colouration. The addition of the copper compound, as also of the alum, however, serves another purpose than that of merely whitening the bread. Bad flour, which is unfit for bread-making, owing to the decomposition of its most important constituent, viz. gluten, can be worked into a fair *looking* bread; and it has been argued that for this reason, at any rate, the use of alum ought to be allowed. Something might be said in favour of this theory, but for some strong objections, one being that the baker is induced to sell his bread so prepared—not at its real value as a lower quality, but as the best bread—thus defrauding the public; the other being that the alum is decomposed, and joining with the phosphoric acid (naturally joined to certain bases in the bread) forms an insoluble phosphate of alumina. It has been asserted that this is the cause in a great measure of the indigestibility of London bread which foreigners formerly observed. It may also be remarked that the gluten of flour, which is seldom less than 12 per cent in good flour, is in these damaged flours often reduced to 7 per cent, and thus the use of the ingredients I have named, enables the baker to foist upon the public a bread which has its nutritious constituents alarmingly reduced. With regard to the addition of peas, beans, barley, &c., the microscope is the only safe method of detec ion. When, however, mineral matters are added, such as plaster of Paris, bone-dust, china-clay, &c., then detection is simple enough. A small quantity is weighed and ignited. As the natural ash of flour itself rarely exceeds 7lb. per 1,000 of flour, it is quite plain that the addition of mineral matter in quantity sufficient to pay would be at once detected by the increased weight of the ash. I may however state, as my opinion, founded upon an analysis of many samples of flour and bread, that in this country, at any rate, such adulteration (with mineral matter to increase the bulk) is rare indeed. The only real adulterant practised at all is the addition of small quantities of rice and potato flour for the purpose of permitting the flour to retain more water when made into bread, and the addition of alum to improve the appearance of an inferior flour and also to enable it to retain water. The detection of alum is so simple that I think

it not impossible for any person, however ignorant of chemical manipulation, to use the test which I have mentioned.

Butter.—The chief adulterations of butter are practically the following: The addition of too great a quantity of salt, the permitting in the manufacture too large a proportion of water to remain, and the substitution of a greater or less proportion of some other fat for butter fat. Occasionally, also, too much casein, or curd, is left, which is one cause of butter becoming rapidly rancid. In this case a large proportion of water is also left in (in fact, some whey is left in), and to prevent rancidity, so great a quantity of salt is introduced as completely to hide the flavour, if it is good butter. Thus butter may be completely spoiled in the attempt to obtain a greater yield, by leaving in too much water, which, as I have said, contains as an accompaniment a quantity of curd. The substitution of other fats is, however, the chief adulterant, as in most cases the palate and the eye will detect excess of either salt or water.

Of all articles of food, butter, until the recent Adulteration Act, was least known to chemists, and the wonderful progress made since then in this branch of food analysis proves that, within reasonable limits, the demand for improved methods of analysis will create the supply. Whilst many chemists were engaged in investigating this matter, Messrs. Angell and Hehner made the discovery which is the keystone of the new process of butter analysis. They found that in animal fats, without exception, obtained from the dead animal, certain insoluble fatty acids existed in the proportion of 95 per cent of the whole fat. It was also found that if 100 parts of pure dry butter fat are taken they contain 86 per cent in first-class to 88 per cent in inferior butters of insoluble acids. Now what causes this difference between 95 per cent and 86 per cent, which equals 9 per cent? To what is this difference due? On examining the subject it was found that it was caused by the presence in butter fat of 9 per cent of soluble matter, which the authors of this process are of opinion is butyric acid. Whether this soluble matter is or is not entirely butyric acid does not at all affect the result of a butter analysis. In effect, if a weighed portion of so-called butter fat, freed from moisture, casein (or curd), and salt, does, on analysis, give *more* insoluble acid than 88 per cent, the amount of fat added to it is proportional strictly to the difference. Thus, roughly, if the insoluble acids amounted to 90 per cent, then the butter is adulterated to the extent of 30 per cent with foreign fats. The process is rather too complicated for exhibition, but it may be thus briefly described. A portion of the

sample to be examined is gently heated until only the pure fat remains as an upper stratum in the glass tube used. The fat is now poured off through filter paper, so that no salt or curd is mixed with it. A weighed quantity of the pure fat is then heated with an alkali (as potash) in alcohol, until the fat is converted into glycerine and a soap like soft-soap, which is fatty acid and alkali. To this soap a mineral acid is added, which acid seizes the alkali and sets free the fatty acids. In butter proper, the fatty acid, when washed and freed from mineral acid, potass, and glycerine, will only weigh 86 per cent; whilst in beef fat, mutton fat, and other similar fats, the resulting insoluble fatty acid will equal 95 per cent of the original fat.

An additional test of the purity of the sample of butter examined is found in the specific gravity of the fatty matter. Mr. Bell, Principal of the Somerset House Laboratory, first introduced this test, which has since proved of great value to the analyst.

During the past three years, amongst other samples, two samples of so-called butter were brought to me for analysis. One was the venture of an ingenious Yankee, and in appearance and to the taste resembled really fine butter. He was desirous I should give him a certificate as to its genuineness, but the first few preliminary tests showed it was not composed of butter fat; and when I declined to give him the certificate, he told me he had tried two or three ports in the United Kingdom, but could from no analyst obtain a certificate as to its genuineness, although all were willing, as I was, to certify as to its wholesomeness as a butter substitute.

The other sample was also factitious, and was the product of an equally ingenious Englishman. It was by very much the best imitation, and would answer to almost every test.

French and Dutch imitations are now to be purchased equalling these in every respect. All these imitations, however, reveal themselves when the test of the quantity of insoluble acids is applied.

I may mention, as my opinion, founded upon considerable experience, that if the prejudice (inseparably connected with any imitation, however good) could be removed, these imitations of butter would soon, *under the name of butterine*, be more largely purchased than they are, for they are preferable to three-fourths of the salt butter now sold in this country; and their introducers deserve some thanks from the community, since by their means butter itself has been kept at a fair price.

Milk.—If for grown-up people bread may be considered the

staff of life, milk is of much more importance, since our infant population may be said to be almost entirely dependent upon it for life. I need not therefore insist upon how important it is that its purity should be assured, or that it should be deemed nothing less than a crime to adulterate it either by the addition of water or the removal of the cream, by either of which fraudulent processes its value as an article of food is so much reduced. For very young children it is of course necessary to dilute the milk, but if the milk has already been reduced by the vendor, it is plain that the next dilution by the purchaser, before its use as an infant food, will bring it nearly to the state of water. The adulterations of milk, I have much pleasure in informing you, are few in number, and not difficult of detection. The old and now exploded ideas of either chalk or calves' brains need only be mentioned to show their absurdity. Chalk would simply sink to the bottom of the milk-can, and would thus be immediately detected, whilst if the supply of calves' brains should be equal to the demand upon it for such a purpose, this adulterant would certainly require clever manipulation to mix it with the milk so as to conceal its presence from the eye of the purchaser. The simple fact is, that practically the adulteration of milk is always accomplished by one of the three following methods, namely, by the addition of water in quantities varying from 20 to 50 per cent; the skimming of the whole milk and its subsequent sale as new milk; the addition of skim milk to new milk and the sale of the whole as new milk. Before proceeding to show the easiest methods of detecting these adulterations, as also the fallacy of the so-called lactometer test, I will briefly define milk, so that we may know the body with which we have to deal. Milk may be defined to be a solution in water of certain substances which are compound bodies chemically, but which, for our purpose, we may assume as simple bodies. They are casein, or curd, lactose, or sugar of milk, and fat, with a small quantity of lime phosphates, &c. These substances occur in milk, as drawn from the cow, in a peculiar state of equilibrium or balance, for, as all housewives know, the least change from cool to warm weather, or the presence of a little acid, suffices to change the solution to a mixture of curds and whey. This equilibrium art has been unable to imitate as yet. We cannot combine curd, milk sugar, and fat, with water, and make the perfect milk. Now the quantities of milk sugar, of curd, and fat, exist in milk in a fairly uniform proportion to the quantity of water. Indeed in genuine milk the casein and the milk sugar and fat do not exist in milk from a dairy of healthy

cows in a lower proportion than 12 parts to 88 parts of water; or, as it is technically termed, there are 12 per cent of solids in milk. In very rich country milk these solid matters range as high as 14·6 parts combined with 85·4 parts of water. Many hundreds of analyses have been made during the past two or three years, with all the modern appliances, and I may state that the quantity of solids which I have named as a minimum in genuine milk, from any dairy, is below that found by Mr. Carter Bell in his analyses of milk from Salford dairies, as well as by myself.

I shall now, in showing the method of detecting adulteration, first deal with the lactometer test. By lactometer is generally understood a small glass spindle, with glass ball, partially filled with mercury. The spindle is marked with certain numbers, which profess to denote the quantity of water which has been added. Its principle depends upon the fact that it floats high in dense liquids, such as milk, and is more deeply immersed in light liquids, such as water. Thus, when placed in water, the whole of the spindle of the instrument is immersed, whilst, when placed in the milk, a portion only of the spindle is immersed. It is thus plain that if some water were added to this milk, the mixture would be lighter than the milk, yet heavier than the water, and thus the spindle would rest in it at a different height, an intermediate one. Now at the first glance it appears that a correct result must be obtainable from the lactometer test; and such would be the case, but for a reason which I will now give. Although, as I have said, casein, lactose, and fat, are always present in milk, in a proportion ranging from 12 per cent to 14·6 per cent, yet it is practically the fat only which varies in quantity. Thus the lactose and the casein, together with the mineral matter, are in a genuine milk never below 9·2 per cent of the total milk, whilst the fat varies from 2·8 per cent to 4·6 per cent. Now casein and lactose, as they exist in milk, if added to water, would make it heavier than water in the following proportion: If this measure-full of water weighed 1,000 grains, an equal measure of the mixture just named—casein, lactose, and salt—would weigh 1,029 to 1,030. If now we add to this mixture the fatty matter or cream, and shake the mixture, we shall find the weight of it decrease in proportion to the quantity of the fat or cream added; a large quantity of cream might reduce the weight to 1,027. Thus, then, a mixture very rich in cream, and in all other respects genuine, might, by the lactometer test alone, be mistaken for a mixture of ordinary milk with water. Again, a rich milk (specific gravity 1,027), containing much cream, would rise in gravity by the addition of water, and thus the lactometer again fails.

There are two methods in use for detecting the adulteration of milk, whether the adulteration consists of added water or skimming off the cream. One process, which depends upon the solubility of fat in ether, gives no indication of the amount of water added, but only shows the amount of fat. The more accurate one is as follows: A weighed quantity of the suspected milk is placed in a platinum basin over a water bath, the temperature of which is never higher than 212°. After about two hours' drying nothing but the solid matter of the milk is left. This, which consists of casein, lactose, and fat, is carefully weighed, and if it equals more than 12 per cent of the original weight of milk used, it may be considered as *prima facie* evidence of its purity. The next step is to warm this residue or solid matter with repeated quantities of ether, which will dissolve out all the fat or creamy matter. When this ether solution of fat is warmed on a water bath till all the ether is gone, and then weighed, we shall know how much fat there is, and, by subtraction, the quantity of solids without fat in the original milk. Another portion of milk is dried and burnt in a platinum crucible, and the mineral matter left, called the ash, is carefully weighed; if it exceeds ·76 per cent of the original milk, it is qualitatively examined. Thus no chalk or salt can escape detection, as one grain per hundred of either, added to milk, would add so immensely to the ash.

For cream, a quantity of the milk is mixed with an equal bulk of warm water. After the lapse of some hours, under proper conditions of temperature, the cream collects at the top, and the quantity can be read off in percentages, as the tube is marked to hold 100 parts of milk. Another portion of the milk is carefully warmed, and a few drops of acetic acid being added the whole of the casein is precipitated. This is in effect curdling the milk, and the whey remains. This whey is carefully weighed in a specific gravity bottle, holding 1,000 grains of water, and from these data the purity of the milk may be very accurately determined.

Before I conclude this part of my subject I should like to make a few remarks concerning condensed or preserved milk. There can be no doubt that these articles fulfil a very important duty in the dietary scale. They enable us to supply ourselves with genuine standard milk, mixed with sugar, at one regular price all the year round, and also provide us with an article which, even in the hottest weather, will keep sweet for a considerable period. Now these are boons which heads of families cannot too highly appreciate, since the souring of the milk, which enters so largely into the diet of children, is a fruitful source of disorder. I have, however,

one word of warning to give—only buy the best brands. I can name two firms whose manufacture is perfection—the Swiss, and the Aylesbury Co.'s. These I have analysed, with the following results: Water, 26·8; fat, 8·5; casein, 11·5; sugar, 51·4; ash, 1·8.

Another English make which I have analysed for a large firm in Manchester gave the following results: Water, 25; fat, 3·2; casein, 17·5; sugar, 52·3; ash, 2. This milk is evidently made from a mixture of new milk and skim milk, and the casein has been so dried as to remain a powder. When the milk is liquefied the casein is found as a hard powder at the bottom of the vessel used.

Some time ago a grocer brought to me two tins of preserved milk, one labelled and marked like the last sample I have mentioned, the other with neither label nor mark of any kind. He wished me to compare the two, as they were made by the same man. The unlabelled one was slightly cheaper, but would have to be labelled and sent out at the grocer's own risk. A careful analysis satisfied me that this unlabelled sample was, like the labelled one of the same make, a mixture of new and skim milk, but the skim milk used was soured, and the result was that the resulting compound in the tin was very acid, and almost unfit for food. So much for buying articles without the guarantee afforded by a respectable name.

Tea.—In the year 1669 the East India Company made their first importation of tea. It consisted of two canisters = 143lb., and was sold at 50s. per lb., after which, for a hundred years or so, its import gradually increased. In the report of the Committee of the House of Commons, dated December, 1783, it is stated that "the quantity of fictitious tea which is annually manufactured from sloe, elder, beech, and ash tree leaves, in different parts of England, is computed at more than four millions of pounds." This was at a time when the whole of the genuine tea imported annually by the East India Company did not exceed six millions of pounds, so that 40 per cent of the tea used in that day was fictitious. Of course the very high price and duty on tea were in that day the chief inducements to imitate it.

The state of the tea trade in 1818 may be imagined when I tell you that no less than eleven persons were fined for fabricating tea from various English leaves, such as sloe, plum, elder, and beech; and fines varying from £70 to £840 were inflicted. The number of manufactories discovered did not indicate the whole of the adulteration, as in that day no method existed of detecting the adulteration when it was completed.

To the eye, the bloom on the tea was imitated by covering the dried rolled leaves with carbonate of copper, if intended for green; and in such quantities was the copper compound added, that a small quantity of tea would give the characteristic blue when ammonia was added to the surface of the tea. The black was finished by means of Dutch pink, copper carbonate, and logwood. In Manchester, in 1843, the following articles were seized upon the premises of a tea fabricator, and had been used: Chromates of lead and potass, arsenite of copper, and carbonate of copper. There could therefore in that day be no question as to the poisonous nature of the adulterants. From the rather unpleasant picture which I have presented, let me direct your attention to the present state of the tea trade. I give it as my decided opinion that no such manufacture of spurious teas now exists in this country. If any enterprising gentleman should invest his money in such a speculation it would certainly not pay him. Science has at any rate achieved this desideratum, that any such clumsy attempts as those made in former days would be at once detected.

With regard to the colouring or facing of tea, I may state that I am of opinion that however innocuous such colouring or facing may be proved to be, yet it is too much to expect us to swallow the dictum that from half-a-pound to two pounds of Prussian blue and other mineral matter per one hundred pounds of tea are of any possible use to us. If, however, the public will still have these coloured and faced teas, they must then run the risk of the enterprising British tea colourer and facer making them occasionally swallow a black tea which has been made into green tea by this facing and colouring. This trade—that is the trade of colouring and facing tea, or making black tea green—existed in this country in 1872, and was carried on until the passing of the Adulteration Act, as may be read in the report of the Select Committee on Adulteration which sat during the year 1874. Mr. James Barringer, who has carried on the trade of facing and colouring as well as defacing tea, in answer to the chairman of the Committee's questions, Nos. 5,914 and 5,915, says: Since the passing of the Adulteration Act I have been employed to remove the colour from tea, but not extensively; in some cases I have put the colour on; but since the decision in the Birkenhead case (better known as the green tea case) I have declined to have anything to do with facing tea.

Having pointed out what kind of adulteration is and what is not practised in this country, let me direct your attention to the real hotbed of adulteration, namely, China. I shall better illustrate

the extent to which they had carried adulteration prior to 1872 by a few facts. A large number of samples of teas were analysed in my laboratory which had been imported prior to the Act coming into force. These were sold by the grocers without the least idea as to the extent of the impurity they contained, and were used by the public in the same blissful ignorance. On analysis they were found to contain the following percentages of mineral matter, being sometimes added sand, in some cases nodules of sand :—

9	samples of	Caper Tea, 1¾, 1¼, 2, 3¼, 4, 6, 7, 10, 10¾.
4	,,	Young Hyson, 1¼, 2¼, 2½, 3.
6	,,	Gunpowder, 1, 1¼, 4¾, 13¼, 13½, 22¾.
2	,,	Pekoe, 6¼, 10.

As will be perceived, the chief adulterations here consist simply in the addition of something, but the Chinese are equally alive to the other and not less profitable method of adulterating, namely, "skimming," or taking away some portion of the virtue from the tea. As the Chinese are not only a tea-producing, but a tea-consuming nation, the fact that tea is drunk as largely there as beer in England must have inspired some enterprising Celestial with the idea of utilising the immense quantity of used tea leaves which are daily produced in all their large towns. I may say that as they only once infuse the tea, or make it, in fact, by simply pouring boiling water once upon the leaves, it was not unnatural for them to suppose that the leaves after their once infusion would be quite good enough for Englishmen—a nation of barbarians who *boiled* their tea occasionally, and always spoiled its flavour by adding cream and sugar to it. At any rate, be the cause what it may, it is a fact that a large quantity of the tea that is annually imported into this country, and known generically as Congou, is much liable to admixture with the used leaves in the proportion of 20 to 30 per cent. As if to verify the inference the Celestials may be supposed to draw, I may mention that in our own country some tea importers likewise have assumed that anything, so that it is *tea leaf*, will do for the British public. In the *Times* of 4th November, 1876, the Commissioners of Sewers inquired into a case of redrying 150 half-chests of tea which had been ducked in the Thames, in regard of which the Customs had permitted the owners to redry such tea. The analyst to the City of London had certified that it was fit for human food, although in his certificate he also admitted that a great portion of the soluble extract was gone. Now I do not dispute the

fact that the tea might be fit for food, in the sense that it was not decaying or rotten. I do not, however, believe that it should have been permitted to enter into consumption as a perfect tea, without any notice or label to the effect that it was, like skimmed milk, deprived of its most valuable constituents.

Goundry's consolidated tea is simply the ordinary tea of commerce pressed into blocks by hydraulic pressure. Now tea in its ordinary state as sold contains an average of 8 per cent of water, and in making the consolidated tea almost 6 per cent of water is pressed out. This would at first sight appear an advantage, since one would expect more tea to be left; the fact is, however, that the gain is sufficiently counterbalanced by the loss of the extractive portion of the tea which is forced out along with the 6 per cent of water.

The effect of the Adulteration Act upon tea has been very greatly to improve the quality generally of the teas sold in this country; and such samples as some of those I have given in capers, gunpowders, and Pekoe, although still sold by some large importers to provincial tradesmen, are not so frequently to be met with.

In detailing the methods of detecting the ordinary adulterations to be met with in tea, I must first of all direct your attention to the appearance of genuine tea, both black and green. As you will know, I dare say, although it has been sometimes doubted, it is now an acknowledged fact that the same plant can be made, at the will of the grower, to produce either black or green tea. In fact there are now in China very large districts which once produced one kind of tea which now produce the other, without any change of plant, the real difference being simply in the manipulation of the leaf after it is gathered. I therefore, with the view of aiding you in the detection of adulteration, exhibit to-night specimens of genuine black and green teas. These samples are from the Darjeeling estate, being in fact Indian teas, and are the produce of the same plant.

Now if a beautiful green or pearly whitish-green colour is apparent upon tea, you may see it must be artificial. *This* genuine green does not perceptibly differ from the genuine black. You thus dispose of colour and facing. If on crunching a small portion of the tea between the teeth a gritty feeling is produced, the tea is impure, it contains added mineral matter; if in quantity, as in the capers I have alluded to, it will be unmistakable. The detection of used leaves can be made by estimating the quantity of solid matter left after tea has been repeatedly boiled, and may

thus be roughly calculated. If ten ounces of ordinary pure tea were boiled repeatedly (of course much smaller quantities are actually used for analysis), and the leaves afterwards well dried, they would weigh less than 6½ ounces. If the exhausted leaves from ten ounces weighed more than 6½ ounces, as I regret to say the exhausted leaves of many of the inferior teas as sold do, you may infer the presence of exhausted leaves, in the original tea sold to you, and if, in addition, the quantity of tannic acid (a constituent of tea, present in large quantities in genuine tea, and to which its astringency is due) is low, your inference will not fail to be a correct one.

In a complete tea analysis we have other and more delicate means of confirming the tests given. All our methods are, however, based upon careful analyses of many specimens of genuine teas, and having thus found that naturally the range, say of insoluble matter, never extends *beyond* 65 per cent, we are justified in concluding, all other tests confirming it, that tea containing above 65 per cent insoluble is adulterated with used tea leaves.

In conclusion, I will summarise briefly the chief heads of a tea analysis, giving the explanation of terms used. The extract means all that can be dissolved out of tea by repeated boiling, the matter dissolved out being evaporated to dryness. The insoluble matter means what is left of the leaves after the extract is poured off. The ash means the mineral matter of the leaves which is left when they are burnt in a platinum crucible. The soluble ash means the part of the ash which can be dissolved out by means of water alone. The insoluble ash means what is left when the ash has been boiled with water, and the water poured off. Thus a good tea, well dried first, will give, when boiled, 30 per cent of extract and 70 per cent insoluble. This tea has an ash weighing 6 per cent, and of this ash 3·4 per cent is soluble in water and 2·6 per cent insoluble. If we imagine the tea to be analysed to contain exhausted leaves, or to have been accidentally immersed in water and redried, the changes which will take place will reduce the extract which can be got from it, and will increase the insoluble matter; will decrease the soluble ash and increase the insoluble; and, according as the tea has been much or little exhausted, will possibly present the following results on analysis: The extract may be 20 per cent; the insoluble, 80 per cent; the ash, 5 per cent; the soluble ash, 2 per cent; the insoluble, 3 per cent. This analysis, as rule of three will show you, indicates a reduction of the extract by 33 per cent, or instead of 30 per cent it is now 20. A knowledge of the amount of extract from a once infused tea

gives complete data for calculating the amount of adulteration. The only true method of obtaining a genuine article in tea, as in every other trade in this age of competition, is to eschew low prices in general, and give a fair price at an establishment which has a reputation to sustain.

Coffee.—Introduced in the year 1652. What was called coffee in the years 1803 to 1818 was very often not coffee at all, but as often burnt or roasted peas, beans, and grain of various sorts. In 1818 a large manufactory of imitation coffee was discovered, and on the premises were about 2,000lb. weight of peas and beans, roasted and ground. The manufacturer, at his trial, admitted that he had made and sold the mixture for twenty years. The chemists of that day asserted that the adulterations of coffee were beyond the power of chemistry to detect; in the present day chemists are not of that opinion. In fact coffee is a most difficult article to adulterate, and it could *not* be done if all people took the precaution of having it ground at home. The imitation coffee-berries can deceive no one; the characteristic membrane called coffee-flights is absent from the imitation berry. However, if people will buy ground coffee it is as well to know how to detect the most prevalent adulteration, that is chicory. The process is a very simple one. Chicory is a root containing some starch and sugar, roasted. Coffee is a roasted berry, containing no starch and very little sugar. Coffee, when spread upon water, remains for some time unacted upon by the water, owing partly to the oil it contains, as well as to its colouring properties being much less than those of chicory. Ground chicory, under the same conditions, is immediately acted upon by the water, the caramel or burnt sugar of the root immediately dissolving and colouring the water.

Chicory-root, beet-root, and other similar adulterants, are detected by the microscope as well as by this test. Some years ago, when chicory-root was dear, one firm is reported to have washed and ground some 700 tons of carrots and 350 tons of parsnips to use for the adulteration of chicory, and thus, of course, indirectly of coffee. The ordinary laboratory methods of detecting such uncommon adulterants as roast starches, peas, &c., or oxide of iron, depend upon the colouration of water by a given weight; upon the ash left when a given quantity is incinerated or burnt; and upon the relative weights of the solutions which are obtained when equal quantities of genuine and adulterated samples are boiled. A novel addition to the adulterants of ground coffee has been made during the past year. A clever gentleman has discovered that at the recent prices of dates it would pay to make a sort of jelly of

the fruit and use the stones, when ground, as an adulterant of coffee. This article has been offered for sale in Salford, and an unsuccessful attempt made to introduce it in Manchester. I need scarcely say it is readily detected under the microscope.

Cocoa.—Introduced into England in 1659. The consumption now equals 8½ millions of pounds. This invaluable and nutritious article of diet is rarely used in its natural condition, and so accustomed have we become to its appearance in a more or less mixed state (some do call it adulterated) that I am somewhat of the opinion that it would be advisable to call it in its mixed state chocolate, and thus any doubt as to whether the Adulteration Act would be infringed would be done away with. Cocoa, in its whole condition, would for two reasons be almost indigestible. First, it contains a large amount of husky matter, which is irritating to the intestines, and gives rise to some unpleasant complaints—this is the case with flake cocoa. Secondly, after the husk is got rid of there is a very large quantity of fatty matter in the seed, which is liable to affect bilious people unpleasantly. Of course there is no difficulty in getting rid of the husky matter. When this is done we have, as a result, cocoa nibs. To obviate the difficulty as to the surplus fatty matter two very different methods are employed. In the one a certain percentage of the fat is expressed from the nibs, and thus the result is cocoa minus the husk and part of the fat. In the other, to the cocoa deprived of husk, and ground, a certain proportion of starch or farina and sugar are added, and the result is what is known as soluble cocoa. As will be observed, the result of these two methods is identical in one respect—the fat is reduced to a fairly digestible proportion. But in the first case the whole of the ash is left, and, indeed, is slightly increased; while in the second case the addition of the farina, &c., not only reduces the quantity of the fat, but also, in like proportion, reduces the quantity of the mineral matter present naturally in cocoa. Now, as cocoa ash, or the mineral matter in cocoa, consists in great measure of soluble phosphates—indeed, to the extent of 50 per cent of the mineral matter—it will be seen that the mixture with starch not only reduces the quantity of fat, but also the quantity of this valuable mineral matter, phosphoric acid; and, therefore, I need scarcely say that, in my opinion, the first detailed method has the greatest advantages.

The adulterations of cocoa in years gone by were like coffee—chicory, roast starches, red oxide of iron, and roast peas or beans. These are detected in the same manner as those of coffee, and, I may safely say, do not exist at all in the *cocoas* sold by makers of repute.

Preserved Peas and Pickles.—The only adulteration to which these are liable is the addition of copper in some shape or other, to meet the decided prejudice in favour of a bright green hue. This adulteration is detected with very little difficulty. Copper, when dissolved, or a salt of copper, gives a black precipitate with a compound called sulphide of ammonium, and if in sufficient quantity gives deep blue with ammonia. The old method of detecting copper by immersing the blade of a knife in the midst of the pickles is also an exceedingly ready method. If the knife be bright a reddish deposit of copper will, in a few minutes, be found adhering to the blade.

Pepper.—Of the two sorts of pepper in common use, the white is simply the black pepper decorticated, or skinned. With the exception of a very small quantity of native white pepper, this is the case with all white pepper sold. As the decorticated berry, therefore, when ground, is almost white, it affords unusual opportunities for adulterating with that commonest of all adulterants, viz., farina, or starch. However, it would not be fair to conclude that all peppers are knowingly adulterated by the vendors, who, if wholesale grocers, buy the peppercorns and have them ground.

Some time ago a gentleman sent me a sample of pepper which, on examination, was found to contain 20 per cent of flour. When I informed him of this result, he told me that he was a wholesale dealer, and was in the habit of sending his peppercorns to a certain mill, not a hundred miles away from the Exchange, to be ground. He informed me also that what he sent me was a fair sample of the ground pepper he had received from the grinder in exchange for his peppercorns. Supposing, which was the case, this occurred regularly, he calculated his loss, and the grinder's gain, at £200 per annum from that source alone. I attempted to induce this gentleman to prosecute, but he never has done so, and I can but suppose it must be the business relations which have existed between them which have prevented it. The adulteration with starch is easily detected by means of the microscope, and when carried to such an extent as in the sample named, which I now hold in my hand, the microscope is the easiest detector.

Sometimes sandy peppercorns are ground, and in this case the ash of the pepper tells its own tale, as the mineral matter contained in pepper only varies between certain narrow limits.

Mustard.—This condiment was usually sold mixed with varying proportions of starch; and when the mixture is duly notified to the purchaser, there does not seem any objection to its sale. Genuine mustard may, however, be bought, and when this is asked for no mixture of starch and mustard ought to be sold.

Preserves.—This food, when described on the label or sold as black currant jelly, orange marmalade, &c., should consist of the fruit named, together with sugar. When only the word "preserves" or "marmalade" is used, then there may be other constituents present, such as carrots, apples, melons, vegetable marrows, &c. I have not met with any case of adulterated preserves since 1875.

Respecting the adulteration of the numerous beverages such as wines, spirits, beer, cider, and artificial effervescing compounds, I shall only say a few words, since they are not recognised as food in the true sense.

Wines and Cider.—Wines and cider may be considered natural products slightly changed by a natural decomposition called fermentation, no addition having been made to the original. The chief adulteration of wine is the addition of alcohol, for the purpose, it is stated, of enabling the wine to be kept to mature properly. This is an adulteration which I need not say is exceedingly difficult of detection by any chemical analysis. The palate is, indeed, the chief guide, unless in exceedingly flagrant cases. On the Continent, as we read, they have another and more dangerous adulterant to dread, namely, artificial colouring matter in red wines. In some instances, we are informed, very injurious effects have resulted from the use of wines so coloured. I have myself repeatedly examined coloured wines, more especially claret, but have never detected any such colouring matter in wines sold here. The chief impurity of cider as well as of the compound effervescing drinks is lead in some state of solution. The presence of lead is highly injurious to health, and in many cases lead paralysis has supervened before the source of the poison was discovered. Although this impurity can be easily avoided by proper care in the use of leaden pipes in the plant or manufactory, it is still much more common that it ought to be, and possibly many obscure forms of disease are the result.

Whisky.—The only adulterant other than water that I have found used is capsicum. This hot biting substance is added so as to conceal the weakness of the diluted spirit. I have not found any added matter injurious to health. I take this opportunity of remarking that all new whiskies contain a compound called *fusel-oil*, *which there is little doubt is the cause*, rather than the strength of the spirit, *of the evil effects* which so frequently result from the use *of raw spirits*. The only remedy for this is the interference of the revenue authorities, and as they are perpetually interfering in every stage of the manufacture of spirits for the sake of the revenue, it could not do much harm if they interfered on the score of public

health. All that is required is, that no spirit should be permitted for consumption from the distilleries under a year from the day it was distilled. This would secure a much better article, and if the sale of spirits cannot be stopped entirely, it might at any rate be rendered as little dangerous as possible.

Gin is a compound for the manufacture of which there are dozens of methods. The chief constituents are, for unsweetened gin, juniper berries, coriander seeds, almond cake, angelica root liquorice powder, and sometimes tincture of capsicum or grains of paradise. To make sweetened gin a certain quantity of sugar is added. These gins are made of any strength the manufacturer or rectifier chooses, but the strengths sent out to the retailer are 17 and 22 per cent under proof. As spirits are accompanied by a Government certificate stating the strength, the law holds that they must not be diluted or changed in strength without due notice to the purchaser. The addition of water without notice is therefore deemed an adulteration.

Beer is also a compound article, and has, since its first introduction as a beverage, altered in character very much. In earlier times it was but an infusion of malted grain, which was then fermented and partially alcoholised, and drunk sweet, being in fact the nearest approach to malt wine that existed. After a time it was considered desirable to keep a quantity on hand instead of making it from hand to mouth as had been usually done, but the beer as just described would not keep long, so that some substances had to be combined with the fermented infusion which would prevent its entire decomposition. For this purpose various sweet herbs and spices were used. Cloves, wormwood, chamomile flowers, &c., were the principle additions made. Hops were introduced about the year 1509, and were used in combination with the above spices and bitters. The people, however, evinced great objection to the use of hops, and in the reign of Henry VIII. an Act was passed prohibiting their use in beer. At a later period, when the hop plant had taken root and flourished, the Government of that day laid a tax upon hops, and to create a revenue, hops were the only bitters allowed to be used in beer. In 1864 the hop duty was repealed, and no restriction was placed by the revenue officials upon the use of any wholesome bitter in brewing beer. As was the case during the time when hops alone were allowed to be used, so now some unscrupulous or ignorant brewers may be found who use any cheap bitter, be it that of common, ill-flavoured, cheap hops, or even deadly poisons, such as picric acid. I have never yet found in any English brewer's beer—and

I have examined a few thousand samples—any poisonous or injurious ingredient whatever, and I am convinced the use of such ingredients is rare and confined to small brewers.

At intervals paragraphs go the round of the papers which may fairly be called sensational. They present to us such alarming pictures, that, unexplained, no great stretch of imagination is required to fancy we are all being slowly but surely poisoned.

A fair example of what I mean has recently been attracting attention. It was really an abstract from the Inland Revenue Laboratory Report, and was, of course, properly regarded as authoritative. Eighty-nine samples of beer and materials used in brewing had been examined in that laboratory, and of these sixty-one were found to be adulterated. This large proportion of adulterated samples appears rather alarming, but when explained neither the proportion nor the kind of adulteration will cause much anxiety. The Inland Revenue chemists examine each year many thousands of samples of beer, and have not found any adulteration in them. The eighty-nine samples named in their report are the samples which were taken in one year by the Inland Revenue officials all over the United Kingdom. They were obtained under such conditions as made it certain that they would be adulterated, in the Inland Revenue sense—in many cases, indeed, the actual adulterant was found upon the premises of the offender. From such samples it is scarcely surprising that sixty-one were found adulterated. The adulteration so called, however, consisted mainly in the addition of sugar or treacle to the beer after it was brewed, and was not an adulteration in the ordinary sense so much as an evasion of duty. The Select Committee on Adulteration in 1874 reported: "Water is often added to beer by the publican, perhaps with the addition of salt and sugar, but few of those villainous compounds with which malt liquors were formerly adulterated have been recently discovered by analysis."

With respect to the other and original constituent of beer, many people will no doubt hear with surprise that malt, the staple of English beer, as it exists in the English imagination, is scarcely used at all in the manufacture of some beer. In nearly all beers malt has been largely replaced by a compound known as glucose, a form of sugar made from potatoes, Indian corn, &c., or by common sugar itself. It is in evidence with regard to some of the sugars used instead of malt, that they contain considerable percentages of salt, which may thus be introduced (by brewers ignorant of the fact) in such quantities as to cause the beer to produce, instead of to allay, thirst. With regard to the instance given sometimes of so-called adultera-

tion of beer by adding water to it, I may state that this form adulteration cannot be detected, because there is no standard s up for beer. Brewers can, by the addition of more water, or le sugar or malt, in the process of brewing, make a beer as weak they choose, and one cannot distinguish water added afterwar from the water introduced in the process of manufacture. Equal fallacious is the percentage of alcohol present in beer as an indic tion of its value, for by fermentation a beer containing only half tl quantity of malt that has been used in another beer may be mac equally strong so far as alcohol is concerned. Thus, in illustratio Allsopp's and Bass's beers, brewed at what is called the origin gravity of 1066, do not contain as much alcohol as some bee brewed from two-thirds the quantity of malt or sugar, but whi have been more fully fermented. Thus the value of a beer is n to be tested by its strength, but by the quantity of material us in brewing it, and this is deduced from what is called its origin gravity. I am convinced, however, that for beer a standard strength might easily be laid down based upon the fact that f public sale only three qualities of ale are recognised, and in the it is attempted by other brewers to keep as closely as possible the standard set up by the great Burton brewers. It, is ho ever, evident that unless, as in the case of gin, the Governme officials, or some body equally competent, fix a *standard of streng and composition for beer*, the public and the public analyst mu be continually groping in the dark. A good precedent for such standard is found in the fact that a long time ago this was don for a duty was levied upon beer, which beer, to simplify t collection of the taxes, was allowed to be brewed at certa strengths only. For the present, however, and until a standard set up, with beer as with all other compound articles vended open market, one can only be sure of the best article by purchasi it with a recognised name as guarantee. In this particular t Burton bottled ales are a striking example.

After having gone over the two portions of the subject—Wh is adulteration? and How is food adulterated?—we come to branch of the subject not less important than those just treated The question is often asked why so little is done to check adulte tion, and why the power given by the Act to the authorities cities, &c., is so frequently kept in abeyance. In many towns t Act is pressed with energy, whilst in others little or nothing is don The real cause is that the Act is not a compulsory one, and do not define the work to be done, and that the authorities of tow do not of themselves feel justified, where expenditure of mon

would be necessary, in taking the matter up without the expressed feeling on the part of the taxpayers. In this, as in many other towns, when the first Adulteration Act was passed the appointment of an analyst was made. The salary was proportioned to the expected duties of the post, which it was supposed would be almost a sinecure, as very few were sanguine enough to expect any practical result for years. To do the work thoroughly, it has been suggested that large towns such as Manchester ought to have each a special laboratory in which all sanitary matters could be treated. In such a laboratory not only food analyses but all needful sanitary experiments, as upon air, water, and sewage, could be conducted, with a view to a systematic investigation of these matters, instead of the rather spasmodic, though valuable, investigations voluntarily undertaken. That this is not altogether Utopian, from its extravagance, as would at first sight appear, the following calculations will show. The cost of such a laboratory and its maintenance for this city would be amply covered by the payment by each ratepayer in Manchester of the sum of one penny per quarter. As a fair example of the benefits all ratepayers would derive from such a policy, I would draw your attention to the fact that *in milk alone the saving to the ratepayers* effected by the reduction of the rate of adulteration during the past two years *amounts to upwards of* £5,000 *per annum*, and at least £5,000 per annum more could be saved if even the low standard of 12% solids were taken. This, let me repeat, is the saving calculated for milk alone.

The mere money advantages are wisely regarded by all of us as by no means of the first importance. This is sufficiently evidenced by the approval of the action of the health authorities here, whose sole object is to save life, and whose success is sufficiently indicated by the reduction of the death-rate since the formation of a health committee and the appointment of the medical officer of health.

Well, in the question of adulteration, especially of milk, which I have dealt with more fully than any other kind of food, I wish you clearly to see that not only money but health is concerned when milk is adulterated with water. In the *Sanitary Record* of July 27th, and two following numbers, Mr. Ernest Turner gives an account of "Dissemination of Disease from the Insanitary Condition of Milkshops." The portion of the paper to which I would draw attention deals with the result of the addition of impure water to milk. He mentions various instances where it has been proved beyond doubt that the adulteration of the milk with impure

water has been the cause of outbreaks of typhoid and many deaths. We need, however, go no farther from home than to Eagley, near Bolton, and more recently Moss Side, one of our own suburbs, where the outbreaks of disease were very distinctly traced to the milk supply.

The advantages, then, which have resulted from the application of systematic chemical analysis to the detection of adulteration are shown not only in the monetary saving, not only has the quantity of water added to our milk supply been reduced, but the number of adulterators has decreased. In 1876 two-sixths of the samples and in 1877 two-elevenths only were adulterated, thus lessening very materially the chances of such epidemics as those which are, in the opinion of medical men, distinctly traceable to milk adulterated with impure water.

In conclusion, let me remind you that in the case of sanitary reform, as in numberless others, the ratepayers are the only persons who can move in the matter. If they express an earnest wish upon the subject of pure food and pure air, the municipal authorities who possess the power will willingly exercise it.